

THE COMPARISON OF MATHEMATICAL UNDERSTANDING AND CONNECTION THROUGH COGNITIVE CONFLICT OF PIAGET AND HASWEH

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Abstract

Cognitive conflict believed as the process of how knowledge is constructed. There are three the cognitive conflict theory, namely Piaget, Hasweh, and Lee. Piaget cognitive conflict is known as cognitive imbalance. According to him, cognitive conflict is built from imbalance between cognitive structures with information coming from it. Equally, imbalance may be occurs between internal structures with external input. Hasweh cognitive conflict is known as metacognitive conflict. According to him, cognitive conflict built from contradiction between old cognitive structures with new cognitive structure or with is being learned. This research tried to compare mathematics abilities (mathematical understanding and connection) through implementation of teaching material design compiled based on the two cognitive conflict theory, namely cognitive conflict of Piaget and cognitive conflict of Hasweh. Result of the research indicates that mathematical understanding and connection ability of student through both teaching material designs does not significantly different.

Keywords: cognitive conflict, mathematical understanding and connection.

INTRODUCTION

It is widely accepted that understanding is an important part in learning of mathematics. A vast of researches focused and concerned on enhancing understanding in learning of mathematics (Hiebert & Carpenter, 1992). Mayer; Olsson & Rees; Perkins & Simmons (in Hiebert & Carpenter, 1992) asserted that understanding is a fundamental aspect in learning; hence the development of learning model is always related to enhancement of understanding. Thus, mathematical understanding occupies a strategic position in mathematics learning.

Minarni (2013) stated understanding is not independent, but supported and interconnected with all processes in mathematics. For instance, representation of a concept or problem will help one's understanding as it viewed from many points of view. Hiebert & Carpenter (1992) asserted that the ability to relate interconnected mathematics ideas takes part in understanding the ideas. Minarni (2013) identified the poor understanding of mathematics is engendered by student's shortcomings in constructing internal representation of mathematical objects, and portraying mental image into mathematical representation. In addition, Minarni conjectured that the poor of students' ability caused by their weakness in relating internally as well as externally one representation to another, whereas in fact the degrees of understanding is defined by number and strength of the relation. An idea, procedure or mathematical fact will be fully understood when all the ideas, procedures and facts are interconnected in a network with a number of strong connections (Hiebert & Carpenter, 1992), and as students are able to connect their mathematical ideas, they come to profound and stronger understanding (NCTM, 2000). They can see that with mathematical connection, topics in mathematics are interacted to one another. Thus, a strong relationship between understanding and connection in mathematics is apparent.

Teacher needs to encourage students to use their own thinking strategy to develop connections of their mathematical ideas, synthesize new ideas and procedures based on that ideas with a representation (NTMC, 2000). For instance, students frequently use objects and strategies in enhancing their understanding in addition and subtraction by connecting both operations. Teachers also frequently use addition to help students learn multiplication.

Beside connections in mathematics, students' environment may provide opportunity to learn topics of mathematics. Students' experience at home, at school and the association with their community are good instances to develop mathematics connections. An example suggested by National Council of Teacher of Mathematics *or* NCTM (2000); position and direction of trip from one place to another may be used to develop geometric ideas of utilization of coordinate to depict location. Moreover, students can be encouraged to develop map in coordinate system of various routes from home to school. By the map they could determine and compare the distance of the ways they go through.

Both examples described above are the approach which frequently used by teachers in teaching mathematics. When we use conflicts from environment, so that the students understand or learn new mathematics concept, then the conflict presented is Piaget cognitive conflict. In contrasts, if teacher use conflicts from inadequacy of lesson learnt by students in overcome new mathematics problem, it is apparent that the teacher use Hasweh cognitive conflict. The forms of conflicts are briefly shown in figure 1 by Kwon and Lee (2001).

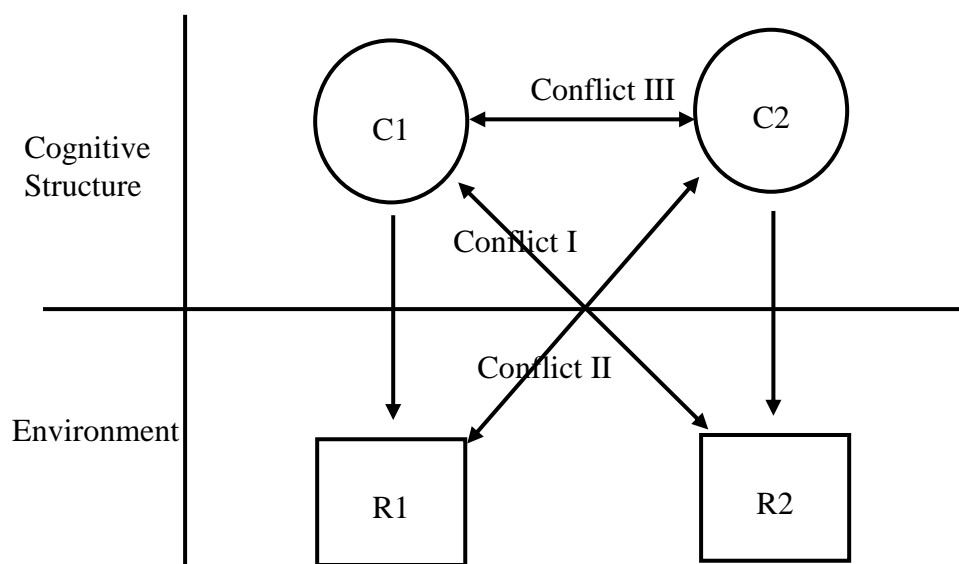


Figure 1. Cognitive Conflict Model (Kwon & Lee, 2001)

Figure 1 shows the cognitive structure comprises C1 and C2; R1 and R2 show the environmental stimulus. C1 depicts preconception of students which probably is of students' misconception. C2 is the concept to be learned. R1 is the environment which can be described by C1, and R2 is the environment which can be described by C2 (Ismaimuja, 2010). Conflict I is Piaget's conflict, which is between C1 and R2, or between preconceptions of student's environment that can be described by the concept to be learned. Conflict II cited by Kwon, the conflict is between concepts to be learnt from the environment that can be described by students' preconceptions. Conflict III described by Hasweh, it is between students' preconception with the concept to be learned.

Since 1980s the use of cognitive conflict as learning strategy is very popular,

particularly in science education (Lee et.al., 2003). Many researchers asserted argumentations about the important role of cognitive conflict in conceptual change. However, the influence of cognitive conflict remains plenty questions. Lee set an example of several types of cognitive conflicts, such as visual conflict, kinesthetic conflict, social conflict between peers and between children and adult (Druyan, 1997), individual conflict and peer conflict (Chan, Burtis & Bereiter 1997). While Zimmerman and Blom (Lee et.al., 2003) examined cognitive conflict assessment which is focused on two topics; degree of uncertainty and response latency or internal cognitive conflict.

The studies on learning practices with cognitive conflict strategy are conducted in various ways. Watson (2002) finds the cognitive conflict strategy helps reconstruction of students' knowledge. Students are easier to connect knowledge to be learned through this reconstruction. This learning activity provides meaningfulness to the students. In addition, cognitive conflict prevents misconception on the students (Maier in Pathare & Pardhan. 2004). Mosham & Geil (1998) and Kruger (1993) in Prata, et al. al. claimed that productive cognitive conflict occurs in context of cooperative learning, not in competition or interpersonal conflict. Mosham and Geil described that productive cognitive conflict does not occurs in the process of independent thinking, but in collaborative construction of conceiving consensus of a problem solution. This notion is supported by Sutawijaya and Dahlan (2011) that interaction with others is source of the occurrence of cognitive conflict. Dahlan et.al. (2012) revealed in their research that creative thinking through cooperatively cognitive conflict is significantly better than individual cognitive conflict.

It is encouraging to study whether the model developed by Kwon & Lee (2003) from Piaget, Hasweh and Kwon can be developed partially in subject matter? And is there influential difference on student's mathematics ability? In this study, only two models will be compared, those are cognitive conflict from Piaget and Hasweh. The mathematics ability to be assessed are mathematical understanding and connections.

RESEARCH METHODS

This is an experimental research that aims to study comparison of mathematical understanding and connection through cognitive conflict of Piaget and Hasweh. Since the researchers did not place students randomly in the class, then this study is a quasi experimental research, with pre-post test control nonequivalent group design.

Sample is selected purposively with consideration that the ability of students in the school where this study is undertaken is considerably equal. The selection of sample is recommended by mathematics teachers who teach in those classes. Two classes are selected as experiment classes. One class used subject matter of Piaget cognitive conflict (experiment 1); and the other class used subject matter of Hasweh cognitive conflict (experiment 2). While the strategy used in both classes is similar, that is adapted from Sugiyatna (2008). The first step is introduction, students are oriented to conflict. In this step teacher explains learning objectives, the necessary learning source, motivate students to actively engage in overcoming conflict and seek the truth of concept. The second step is organizing students to learn. In this step teacher helps students to define and organize learning task related to the conflict. The third step is guiding students to conduct individual as well as group investigation. In this step teacher encourage students to gather relevant information, conduct experiment, and internal discussion to get clarification and problem/conflict solution. The fourth step is developing and presenting learning products. In this step teacher assist students to planning and preparing learning products and helps students to share learning task with peers. The fifth step is analyzing and evaluating. In this step teacher helps students to reflect or evaluate the investigation and all

processes undergone by the students.

In implementation, a collaborative work is conducted by researchers and students who are working on final assignment (thesis). One student conducts research to gather data of mathematics understanding, and one student conducts research to gather data of mathematics connections. Mathematics connection is assessed by instrument with indicator developed by Sumarmo (2002), which is to recognize equivalent representation of similar concepts, recognize mathematics procedure connection of a representation to equivalent representation procedure, to use and assess relation among mathematics topics and relations beyond mathematics, and to use mathematics in daily life. Mathematics understanding is assessed by indicators suggested by Skemp, which are instrumental and relational.

RESULT AND DISCUSSION

Subject matter of the cognitive conflict in this study is developed based on the model of Kwon and Lee (2001). In Piaget cognitive conflict, a contextual problem from where the students learn new mathematics matter is presented to the students. Here is an example of the problem:

There are four types of human blood, A, B, AB, and O. If 5 people examine their blood type, then is it possible that two people have similar blood type? Give your reason!

To solve the problem above, students are encouraged to make possible relations through arrow diagram among five students with their blood types. From that process, it is expected that at least two students have similar blood type. Through the activity students are urged to determine the number of possible relations from set A with n elements to B with m elements.

The subject matter of Hasweh cognitive conflict is designed by delivering students to mathematical problem that related to new mathematics matter. When teacher teaches addition of fractions, For instance, students are asked to determine result of $\frac{1}{2} + \frac{1}{4}$, and the students answer by adding the numerator with numerator and the denominator with denominator, so that resulted $\frac{2}{6}$. Then the students are asked to simplify it that resulted $\frac{1}{3}$. Here the students can see the relation that $\frac{1}{3} < \frac{1}{2}$. With this condition, the students undergo a cognitive conflict.

The conflict built from both examples are naturally similar, that is how new knowledge is constructed by utilizing students prior knowledge. As Herbert & Carpenter (1992) stated that network of mental representation occurs through relation process between new information with students' prior information and understanding will grow and organized through the network built. Glaser (Hiebert & Carpenter, 1992) cited that the existence of networks influence quality of constructed relation that help formation of new network.

As described previously, both classes use five steps cognitive conflict learning strategy, which is student orientation on conflict, organizing student to learn, individual and group investigation, development and presentation of learning product, evaluation and reflection.

The observation revealed that from all learning activity in class experiment 1, the third instruction could not conduct learning activity such as presentation, responding and concluding. It occurred because many students did not finish solving the problem presented yet. In class experiment 2 same activities were not conducted in fourth instruction. Thus, it can be concluded that learning in both classes had well conducted as it planned.

As previously described, this research aimed to compare mathematics understanding

and connection through cognitive conflict strategy of Piaget and Hasweh. The research is implemented in two different schools for each variable assessed. Hence both variables are not simultaneously discussed.

The ability of mathematical understanding result is descriptively shown in table .

Table 1
Descriptive Statistic of Mathematical Understanding Ability

Test	Class Experiment 1		Class Experiment 2	
	\bar{x}	s	\bar{x}	s
Pretest	5.12	2.06	9.87	2.54
Posttest	51.10	4.48	56.92	3.26
n-Gain	0.49	0.21	0.52	0.15

Table 1 show that initial understanding ability of students in class experiment 2 is better than students in class experiment 1. The distribution in class experiment 2 is higher than in class experiment 1. Hence the initial ability of class experiment 2 is higher but the difference among students is much higher than students in class experiment 1.

The posttest and n-Gain revealed that level of data distribution is shifted. The mean of posttest on understanding ability of class experiment 2 is higher than class experiment 1, but the distribution in class experiment 2 is lower than in class experiment 1. Similar result yielded by n-Gain, standard deviation of class experiment 2 is lower than class experiment 1. Thus, treatment applied in class experiment 2; the Hasweh cognitive conflict has lessen the gap of understanding ability among students in the class.

Since the test result on student initial ability of mathematics understanding is different, the n-Gain was employed to examine the influential difference of both treatments on student understanding enhancement. Descriptively, on table 1 we can see that mean of the n-Gain of both classes are similar in qualification, which is middle qualification. Mean of n-Gain for class experiment 1 is 0.49; and for class experiment 2 is 0.51. Table 2 show details of mean distribution of n-Gain of students understanding ability in both classes.

Table 2
Distribution of n-Gain Qualification of Mathematics Understandings Ability

Class	n-Gain Qualifications (g)	Number of students
Experiment 1	High ($g > 0.7$)	6
	Middle ($0.3 < g \leq 0.7$)	28
	Low ($g \leq 0.3$)	7
Experiment 2	High ($g > 0.7$)	5
	Middle ($0.3 < g \leq 0.7$)	32
	Low ($g \leq 0.3$)	2

On the table we can see that number of student distribution of both classes on each n-Gain qualification is relatively homogenous, with the curve tendency towards n-Gain small. This is proven by the result data normality test, class experiment 1 distribution is not normally distributed. This result implicate that the test the difference of both classes use non parametric test, the Mann Whitney U. The result of Mann Whitney U Test is $Z = -1.243$. The Z value is not sufficient to reject the null hypothesis on significance level of 0.05.

The following discussion focused on ability of student mathematics connection. Table 3 show descriptive statistics of connection ability of both classes.

Table 3
Descriptive Statistics of Mathematics Connection Ability

Test	Class Experiment 1		Class Experiment 2	
	\bar{x}	s	\bar{x}	s
Pretest	3.42	3.02	5.59	2.92
n-Gain	0.48	0.28	0.57	0.27

The descriptive statistic of mathematics connection ability resembles the descriptive statistic of understandings ability. Mean of initial connection ability class experiment 1 is lower than class experiment 2, but distribution in class experiment 2 is higher than class experiment 1. Data of n-Gain in both classes are slightly different, mean of n-Gain of connection in class experiment 1 is lower than class experiment 2. This also occurs in data distribution, where n-Gain of class experiment 1 is low but slightly higher than class experiment 2. This result is concomitant with findings on students' ability of understanding that students are familiar with problems related to mathematics application in other subjects and daily life. However, from the data distribution is apparent that Piaget cognitive conflict is able to lower gaps among students. This is very rational, because cognitive conflict built in Piaget is initially introduce to the environment or context used as tool to learn mathematics matter. According to NCTM (2000), real world context provide opportunity for the students to relate what they learn with their mind. In addition, it is suggested to deliver students to questions such as: What made you think that? Why does that make sense? Where have we seen a problem like this before? How are these ideas related? Did anyone think about this in different way? How does today's work related to what we have done in earlier units of study?

The following is result of mathematic connection enhancement test from n-Gain data. The test used non parametric statistics Mann Whitney U Test. The selection of this test caused by one of n-Gain distribution data, which is class experiment 2 is not normally distributed. It is gained with probability of null hypothesis rejection only 0.113. Since the probability less than 0.05, and then the null hypothesis do not rejected. It means there is no difference in students' mathematics connection enhancement through both learning.

The findings described above revealed that Piaget or Hasweh cognitive conflict did not result in significant difference on enhancement of understanding as well as mathematics connection. The non existence of difference from both treatments might be influenced by cooperative activity in the phase of cognitive conflict strategy. According to Johnson & Johnson (2000), in cooperative strategy, interactions, sharing and collaboration of students in group brings success to all students. This occurs by sharing of resources ability and encouragement from each group member. There are significant cognitive activity and interpersonal dynamics so that every student is encouraged to learn.

Consistency of this result needs to be followed by research that concern on factors influence cognitive conflict. As cited by Kang et. al. (2005) that success of cognitive conflict strategy is highly depending on various factors, such as willing and ability of students to recognize conflicts. Thus, Kang et. al. suggest to take logical thinking ability, learning style—classified into dependent/independent fields, and learning approach into considerable factors.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions of this study are as follows:

1. Development of subject matter with Piaget or Hasweh cognitive conflict base is descriptively able to enhance students' ability of mathematics understanding and connection. The enhancement is at middle qualification.

2. Inferentially, there is no significant difference of understandings enhancement between applications of Piaget or Hasweh cognitive conflict. As well as mathematics connection, even descriptively learning with Hasweh cognitive conflict slightly higher, but statistically did not show significant difference.

From the conclusions above we posed some recommendations:

1. The subject matter of Piaget or Hasweh Cognitive conflict can be developed and used by teachers in mathematics learning, so can enhance students' ability of mathematics understanding and connection.
2. The development subject matter for both cognitive conflicts partially is not easy. Hence it is suggested to develop both conflict cognitive collaboratively and concurrence with characteristic of the matter to be taught.
3. For future research, it is possible to develop qualitative study in development of subject matter through didactic pedagogic theory that accommodate students' learning difficulties and related to other mathematics competency.

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